Co-Operative Air Traffic Management (CO-ATM)

Concept and Transition

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Outline

- Motivation
  - Distributed Air Ground Traffic Management (DAG-TM)
  - Trajectory-Oriented Operations With Limited Delegation (TOOWiLD)
- Cooperative Air Traffic Management
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Motivation

- The *Next Generation Air Transportation System (NGATS) Integrated Plan* requires
  "… research to evaluate alternative allocations of air traffic management services and functions between the ground and the air, and the automation and the human, to address critical system attributes such as capacity, agility, cost, human factors, reliability, safety, performance, and transition paths."
- New insights from recent research on *Distributed Air/Ground Traffic Management (DAG-TM)* concepts like airborne self-separation, airborne spacing and trajectory negotiation
- Our NextNAS research on *Trajectory Oriented Operations with Limited Delegation (TOOWiLD)* addresses near- and medium-term transition paths targeting substantial -but probably insufficient- capacity gains (~1.5X)
- Near-term application of *airborne spacing* concepts, *air/ground integration* and research on *multi sector planning* may provide avenue for phasing in new concepts

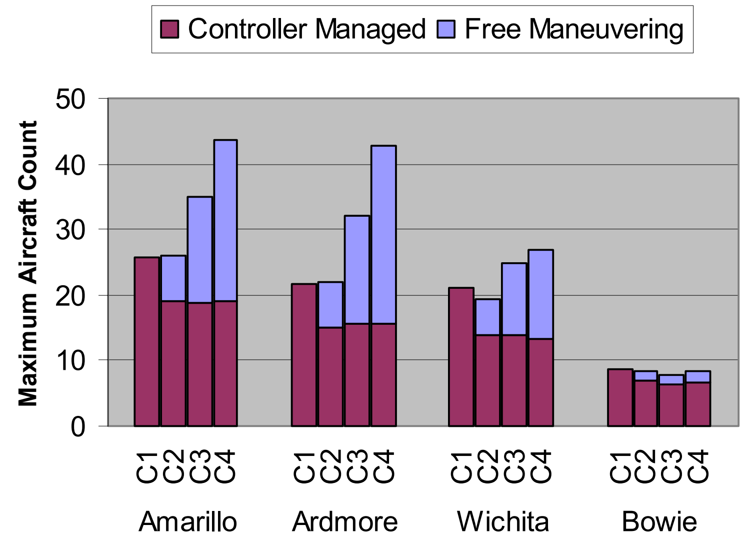
DAG-TM Results on Free Maneuvering: Controller workload in high density ops

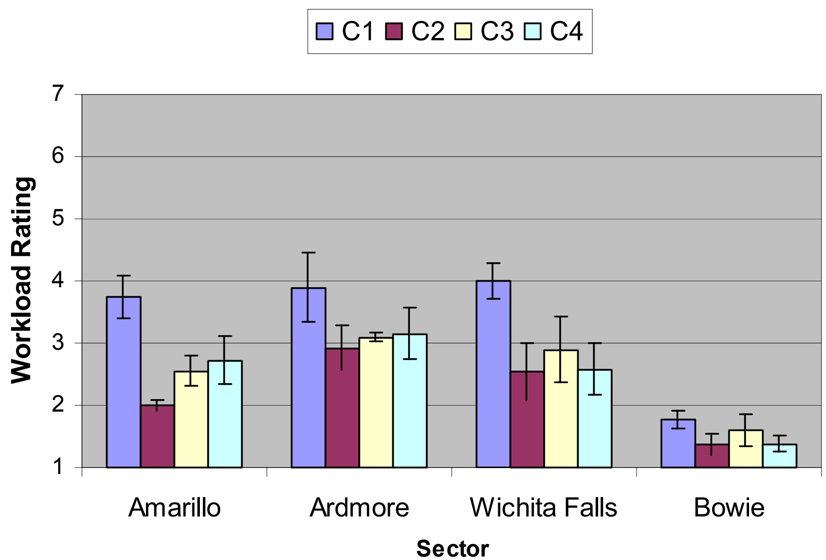
AIAA Guidance, Navigation, and Control Conference San Francisco, CA, August 15 -18 , 2005

- DAG-TM research on *mixed operations with airborne self-separating and controller-managed aircraft* indicates:

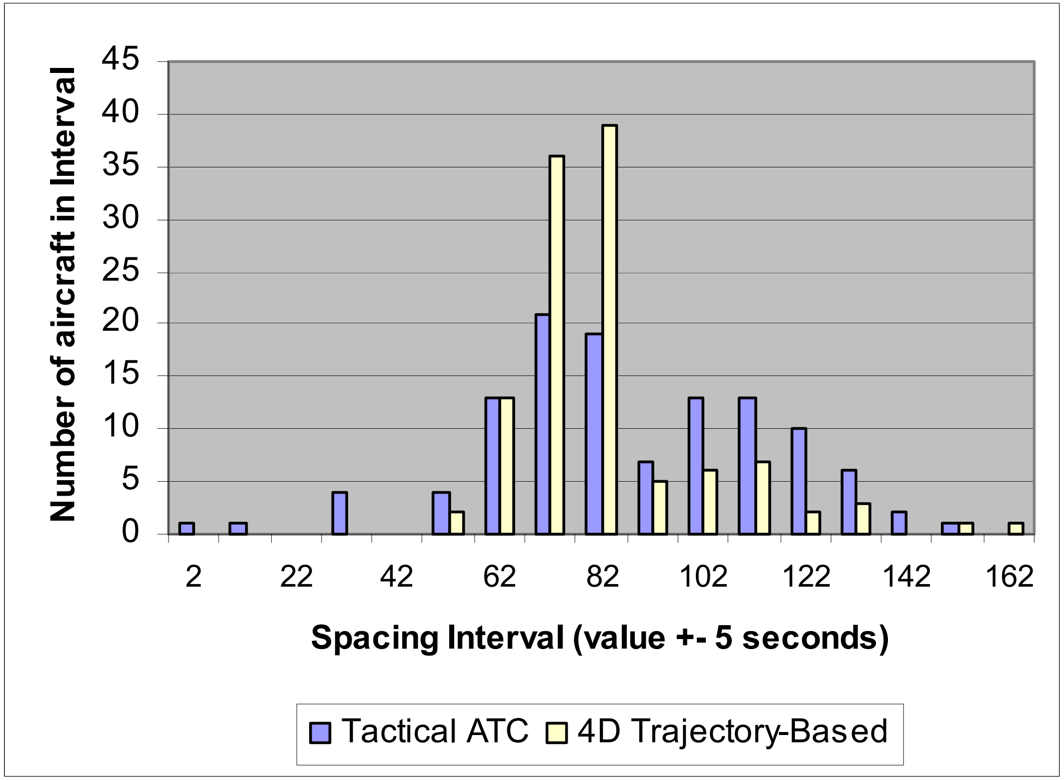
  There is a potential for greatly increasing capacity, if the separation responsibility within a given airspace is split among multiple operators

- A number of safety concerns need to be addressed



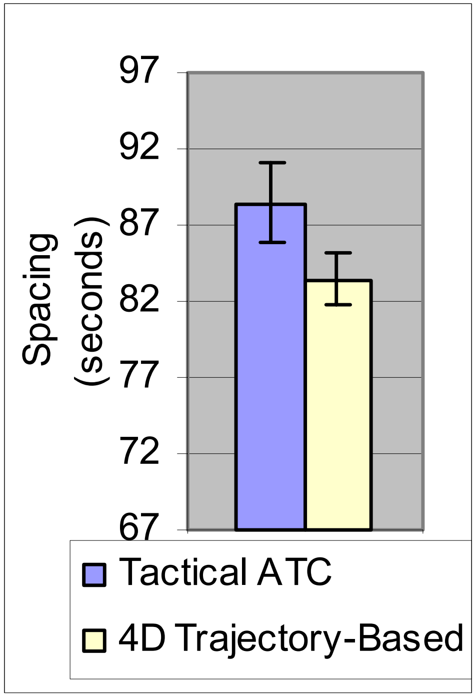


DAG-TM Results on Trajectory Negotiation: Inter-Arrival Spacing at the Meter Fix



Inter-Arrival Spacing Histogram

Inter-Arrival Spacing Mean and Standard Error

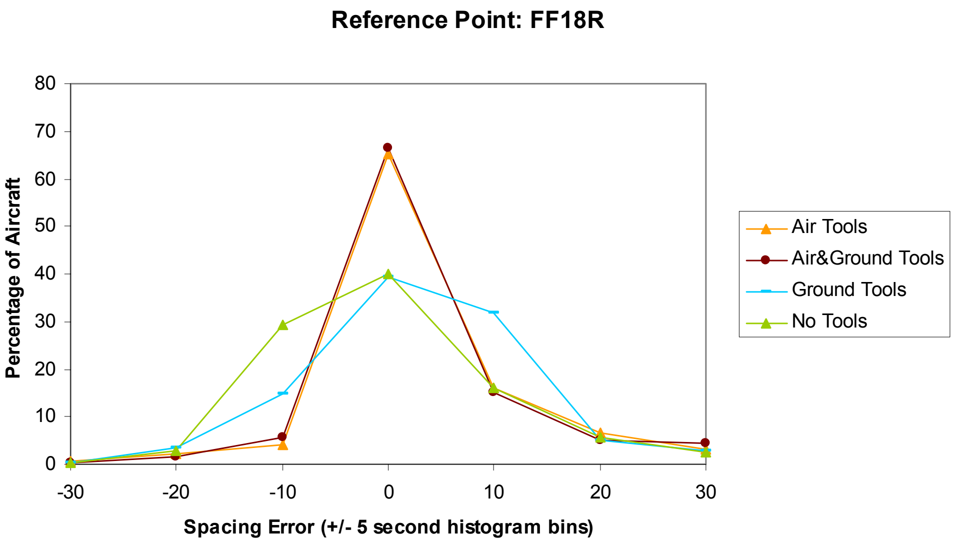


In the trajectory-based condition more aircraft were delivered within their target spacing of 84 seconds and the variance was significantly reduced

DAG-TM Results on Trajectory Negotiation: Controller Feedback

Question	Range	Low Altitude controller	High Altitude controller #1	High Altitude controller #2	En route controlle r		Avera ge
How useful was the ability to obtain speed advisories when trying to deliver aircraft to a meter fix STA?	extremely useful (5) not very useful (1)	**5**	**5**	**5**	N/A		**5**
What impact do you think the ability to datalink clearances had on your overall workload?	greatly reduced (5) greatly increased (1)	**5**	**5**	**4**	N/A		**4.67**
How effective were cruise and descent speed clearances for controlling arrival traffic compared to current operations?	much more effective (5) much less effective (1)	**4**	**5**	**4.5**	N/A		**4.5**
How effective were trial plan route amendments compared to vectoring used in current day operations?	much more effective (5) much less effective (1)	**5**	**5**	**5**	**4**		**4.75**
How effective were trial plan altitude amendments compared to current day operations?	much more effective (5) much less effective (1)	**3**	**5**	**5**	**4**		**4.25**
How useful was the ability to datalink clearances compared to voice clearances?	much more useful (5) much less useful (1)	**5**	**5**	**5**	**5**		**5**

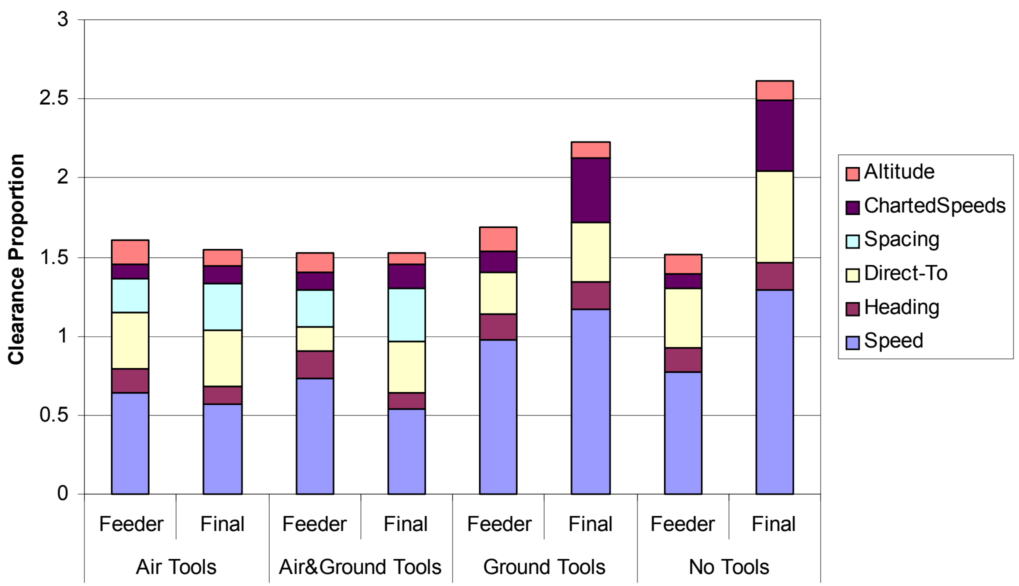
DAG-TM Results on Airborne Spacing: Inter-Arrival Spacing and Clearances



Inter-Arrival spacing accuracy was improved with airborne spacing tools ASAS 2.

Controllers preferred ground & air tools

Number of clearances on final was reduced with ASAS spacing and merging



DAG-TM Results: Our Assessment

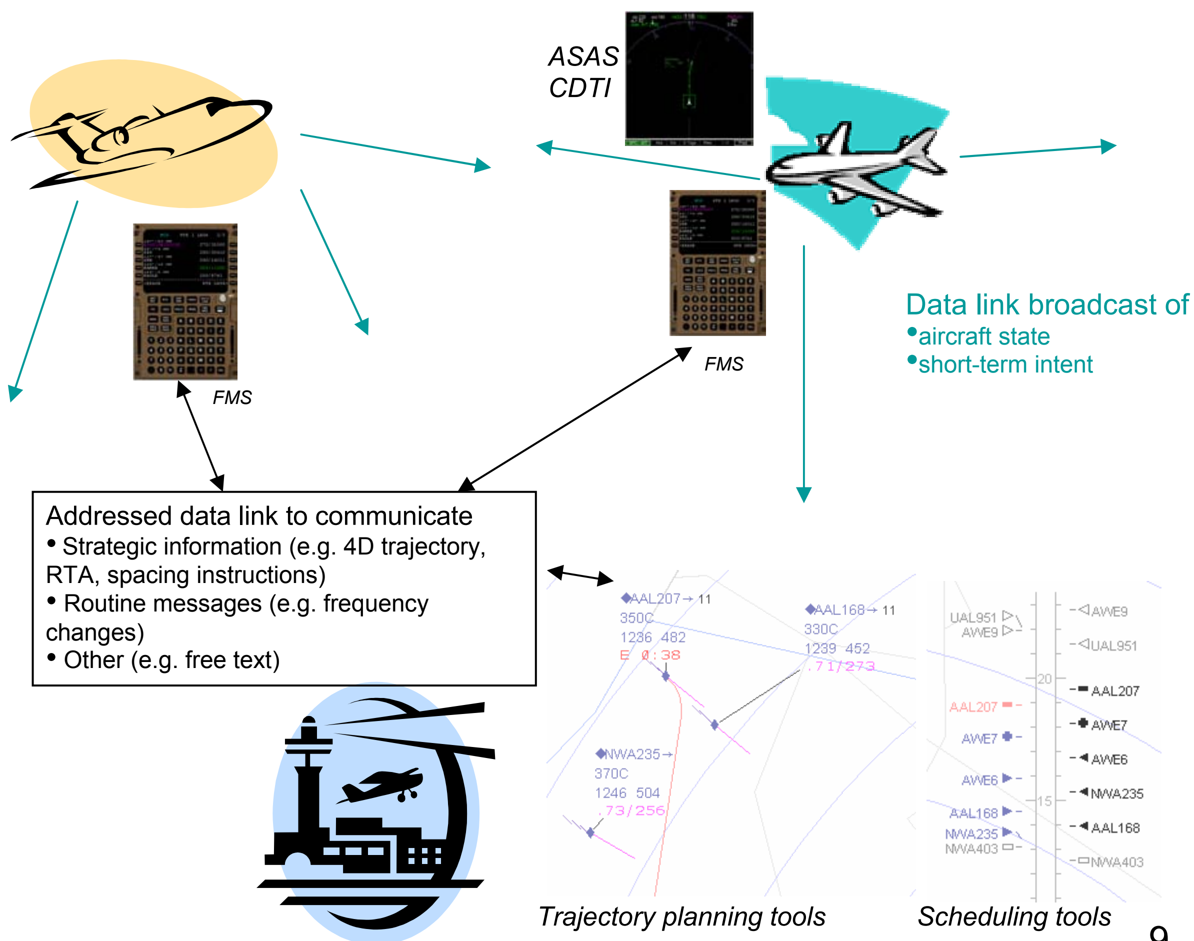
- Trajectory management integrated with data link should be the standard mode of operation in the future system.
- Airborne spacing is a powerful tool for improving spacing accuracy.
- Airborne self-separation has good potential, but requires additional research and further refinements to be safely usable in congested airspace.

Trajectory-Oriented Operations with Limited Delegation (TOOWiLD)

Concept

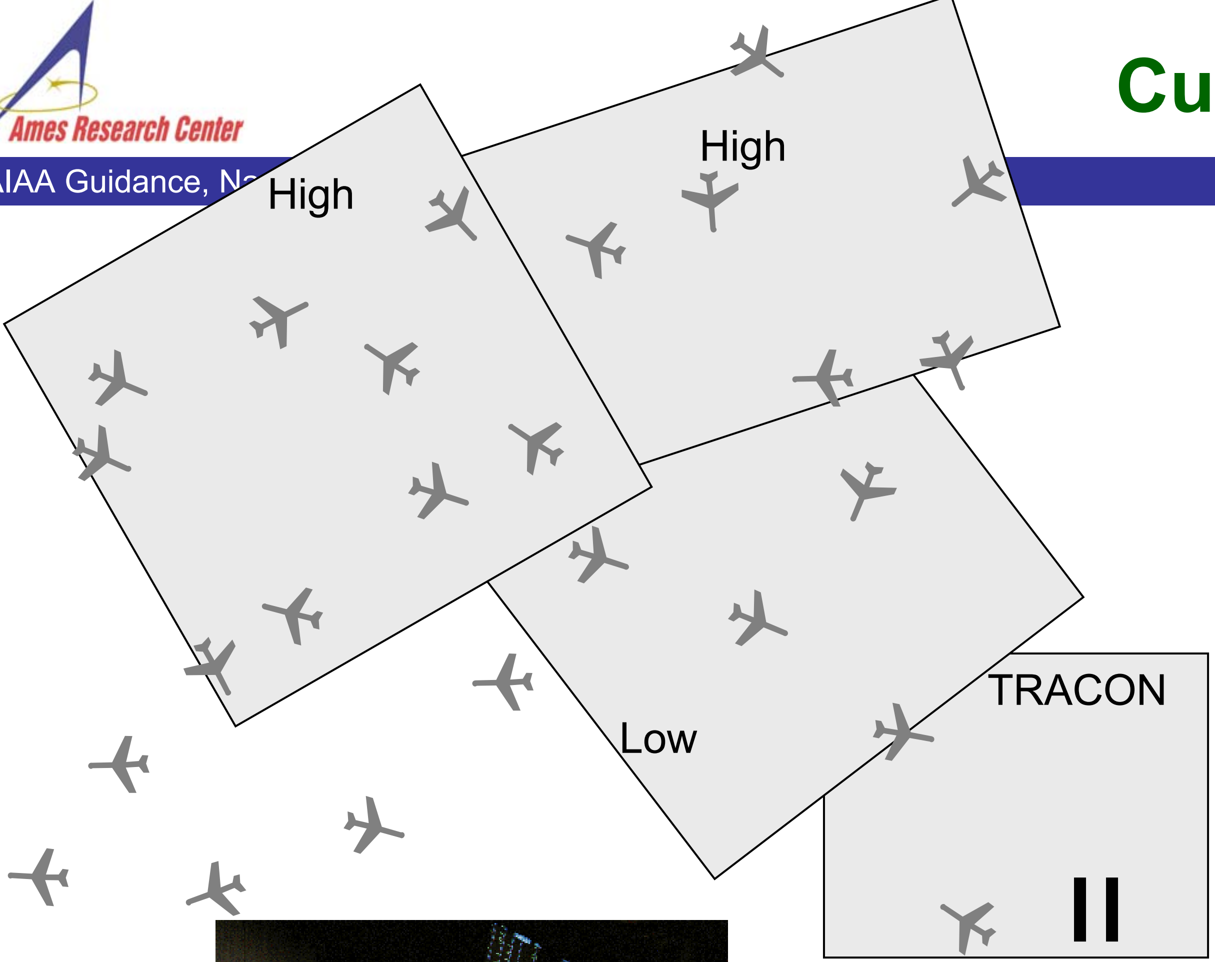
- *Use time-based flow management to regulate traffic density,*
- *Use trajectory-based operations to create efficient, nominally conflict-free trajectories that conform to traffic management constraints and,*
- ***Maintain local spacing between aircraft with airborne separation assistance.***

Integrated Air/Ground System



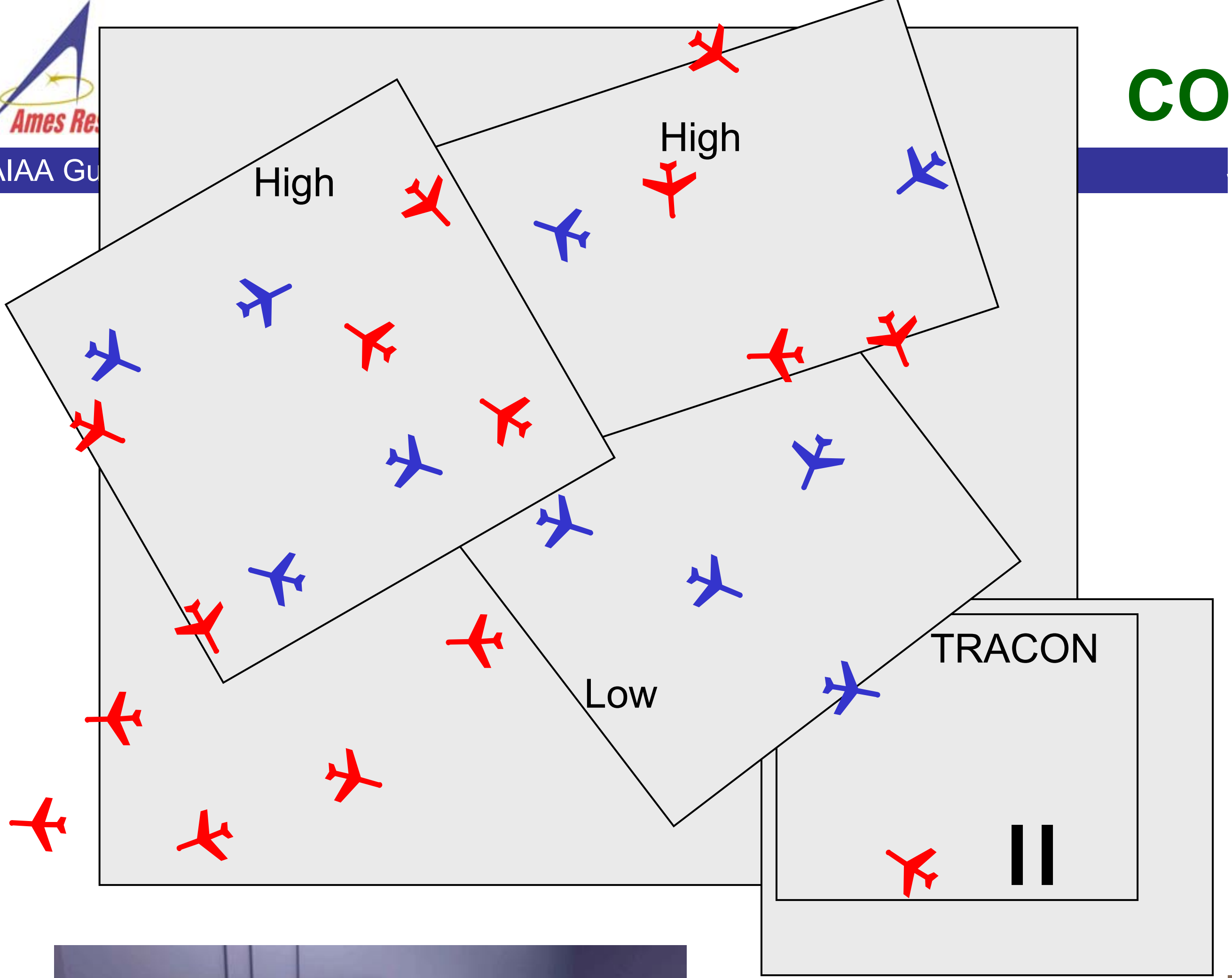
- CO-ATM
  - Integrates ground-based and airborne separation assistance/assurance concepts for the NGATS
  - Gradually introduces advanced ground automation and ASAS to pilots and controllers
  - Addresses mixed equipage issues
  - Is a combination of sector controllers controlling conventional traffic, area controllers and flight crews co-operating to manage equipped aircraft in the same airspace via data link
  - Is targeting substantial capacity increases (2x-3x)
  - Is benefit-driven – 1st aircraft to equip gets immediate benefit

Current Situation



Conventionally R- and D-Side controllers control traffic in given sectors with limited automation support

CO-ATM: Roles



In CO-ATM the traffic responsibility is split between R-Side controllers and area controllers depending on equipage

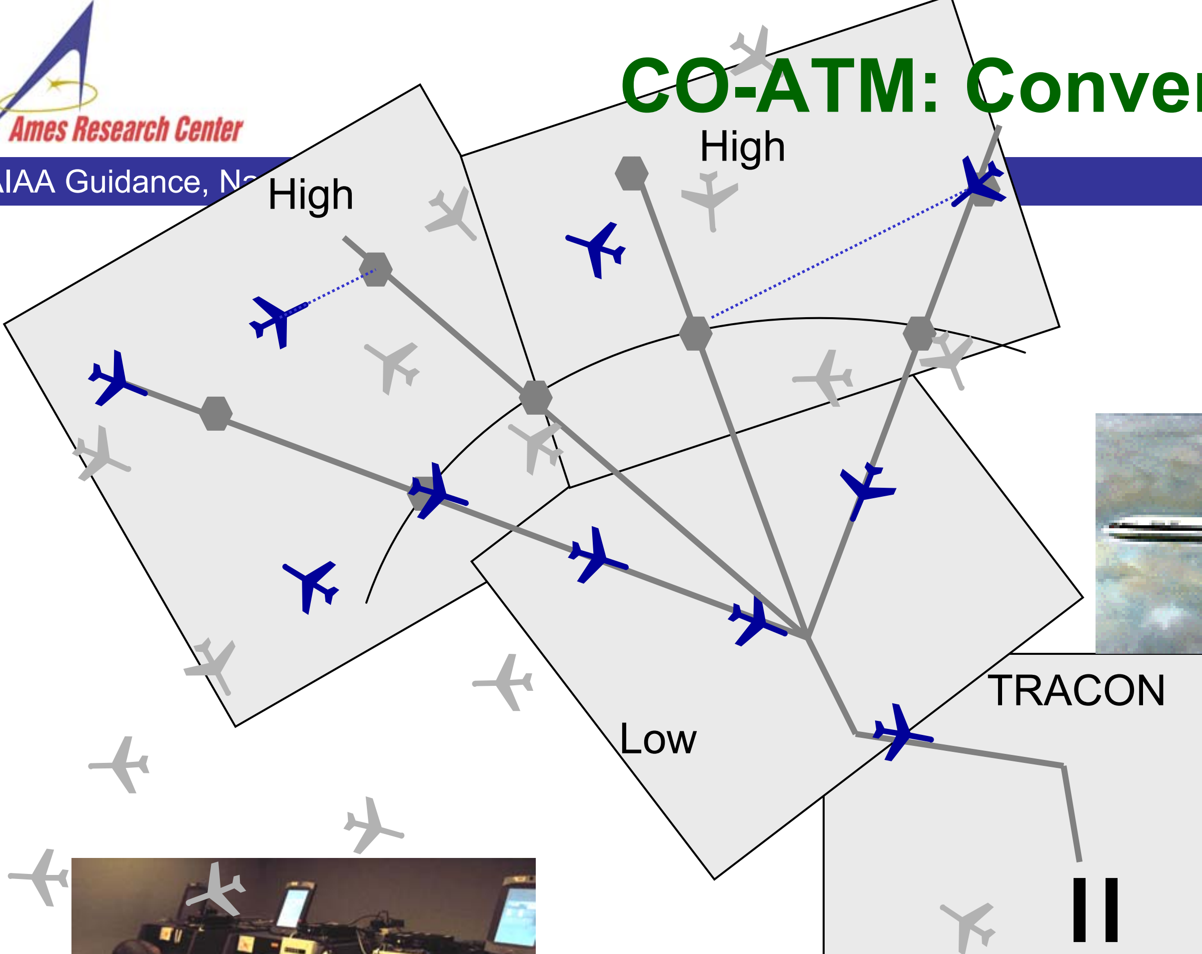
Blue: conventional aircraft (mostly with FMS, some CPDLC)

Red: aircraft equipped with CPDLC/FMS trajectory uplink/downlink + ADS-B-Out ASAS 1 and 2 may be required

ASAS 3 and 4 optional to increase flexibility, efficiency and scalability

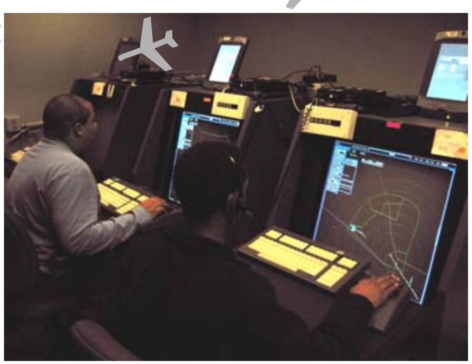
Ground automation monitors all trajectories and alerts responsible controllers

CO-ATM: Conventional Aircraft



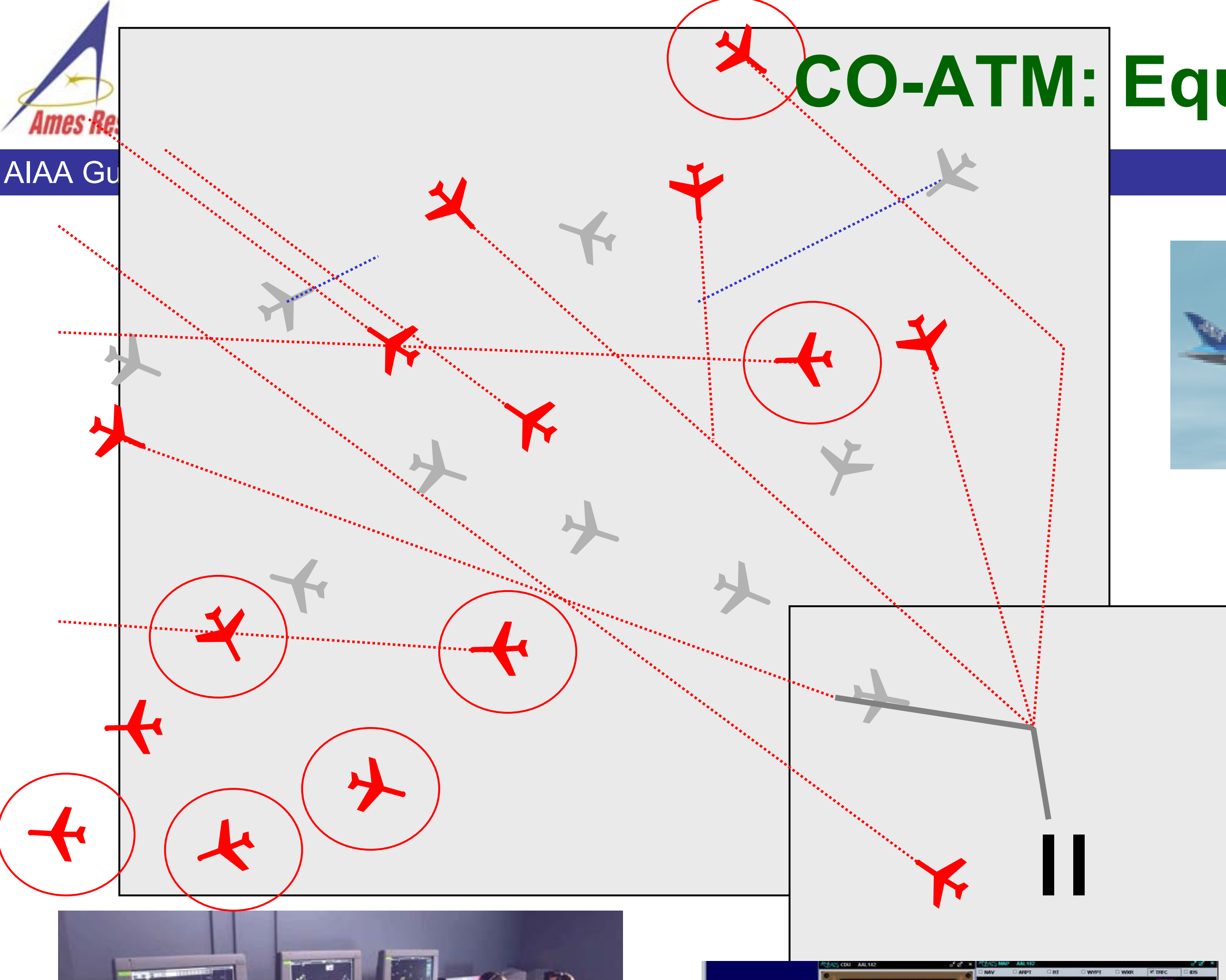
Conventional aircraft are controlled by R-Side controllers using voice for FMS compatible trajectory changes and CPDLC for routine tasks, if equipped

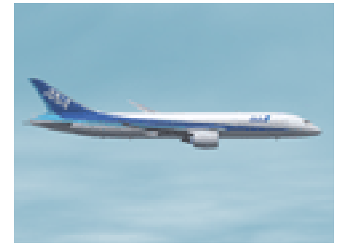
Ground automation monitors all trajectories and alerts controllers



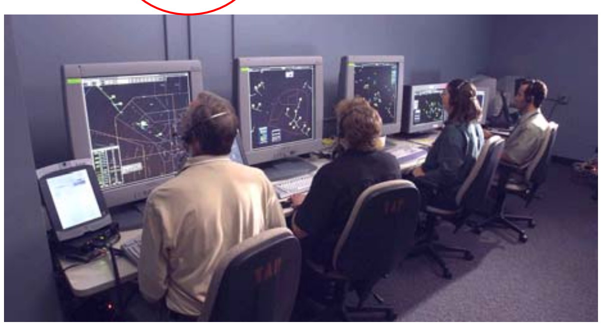
R-Side controllers use FMS procedures and DSTs to increase 4D predictability

CO-ATM: Equipped Aircraft





- Traffic flow of equipped aircraft is managed by area controllers and automation using CPDLC trajectory changes.
- AOC/TMU negotiated landing slots have high priority.
- Voice communication is only used by exception. Automation carries out all routine tasks (e.g. TOC, handoff, point outs)
- Airborne spacing can be used in lieu of tactical speed commands for station keeping.
- Area controllers can assist flight crews conducting autonomous operations in mixed airspace.



Full 4D trajectory exchange between air and ground. Co-operative flight management

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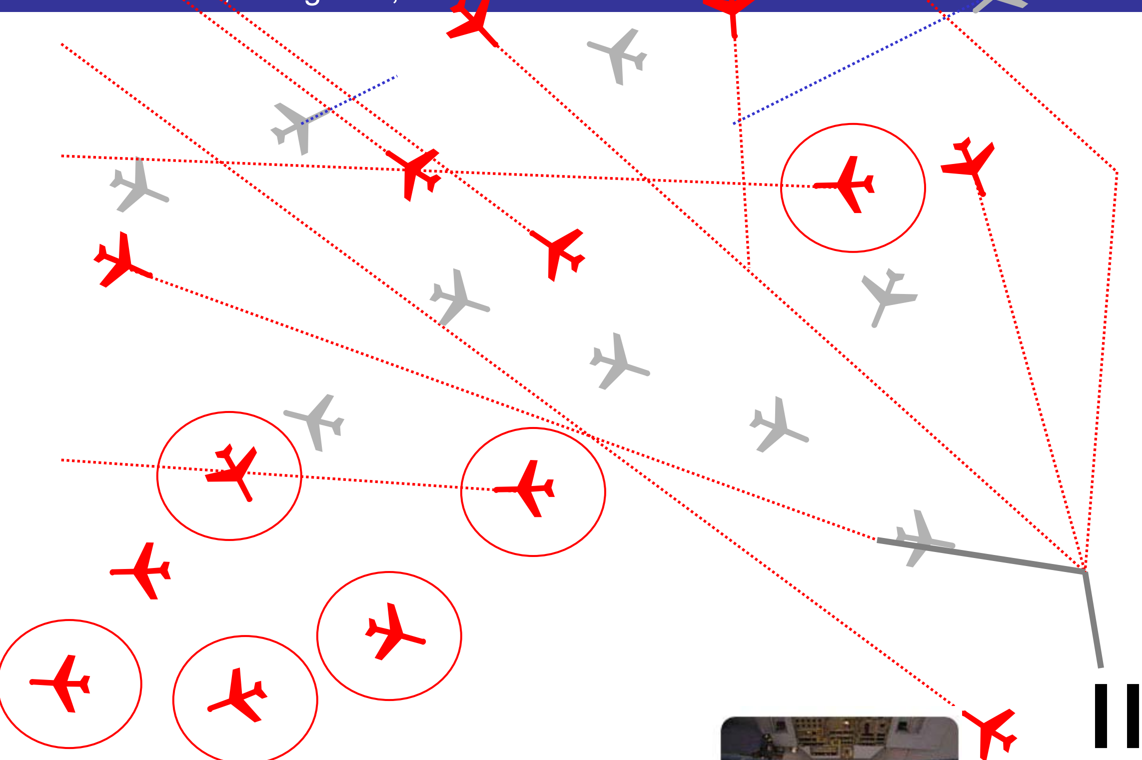
CO-ATM: Flight Deck Operations



- Autonomous operations in mixed airspace are possible with controller concurrence.
- Best weather routes can be handled from the flight deck
- Equipped IFR aircraft can request preferred trajectories.
- Once trajectory clearance is approved by ATSP it will not be terminated without justification
- Continuous Descent approaches should be planned whenever possible.
- FMS usage throughout the flight is required.
- Pilots co-operate in separation /spacing task.

CO-ATM: Key Ideas

- Area controllers supervise autonomous operations and manage other equipped aircraft using ground-based automation and 4D trajectory exchange
- 4D-Trajectories are available for all aircraft:
  Equipped aircraft report reliable trajectory intent, conventional aircraft are managed along predictable paths, which can be provided by the ground side automation
- Ground-side automation monitors all operations
- Air-side automation monitors “visible" operations
- Flight crews can co-ordinate with area controller if necessary
- Area controller is familiar with airspace and flow constraints
- Area controller can coordinate with sector controllers for conflict management
- Sector controllers control conventional aircraft and ignore most equipped aircraft

Transition Path

Primary Goal	Current system	Near-term transition (to 2012)	Medium-term transition (2012 - 2020)	CO-ATM 2025
security, predictability, flexibility and global interoperability **_ATM_**	Flight plan-based, sector oriented ATM. Aircraft are frequently vectored off their flight plans, flight information is imprecise, passed from sector to sector,	Predict and distribute 4D trajectories for all aircraft, increase use of pre-defined FMS routes and use ADS-B-out to improve 4D prediction accuracy, increase use of time-based TFM over miles-in-trail	Integrate trajectory downlink and other FMS data to improve trajectory prediction, communicate STA's to aircraft. Enable aircraft to manage to RTA's if equipped	4D trajectory-based ATM. Precise 4D trajectories are shared between flight deck, ATSP, AOC and other potential stakeholders Trajectories from the aircraft are compared to ground-based expectations for compliance,
Capacity, efficiency, environment **_ATC_**	Sector controllers issue tactical instructions for aircraft heading, speed and altitude changes in local sectors	Add procedures for sector controller to issue FMS compatible and ASAS spacing clearances inside sector, Add area flow controllers with advanced DSTs to coordinate sequence, schedule and FMS route changes with sector controller and AOC/TMU	Integrate CPDLC with DSTs on area positions, increase authority of area positions to data link trajectory changes and ASAS clearances directly to aircraft. Automate sector / multi-sector /TMU coordination	Area Controllers negotiate strategic trajectory changes with pilots of most aircraft and approve/initiate/terminate increased levels of aircraft autonomy via CPDLC Sector controllers control less equipped aircraft and handle local separation problems if requested.
User preferences, All weather operations, Safety **_Flight Crew_**	Flight crew reacts to controller instructions, has very little traffic awareness, rarely uses FMS in congested airspace	Add FMS procedures to make more use of FMS in congested airspace, add CDTI to create traffic awareness, add airborne spacing capabilities to delegate limited ATC task to flight crew	Integrate CPDLC with FMS and CDTI, enable trajectory requests from the flight deck, increase ASAS capabilities and allow flight crew to manage separation to designated aircraft and/or in designated low density airspace	Flight crew manages coordinated or autonomous operations, uses FMS throughout the flight, is aware of the surrounding traffic, exchanges trajectory modifications with area controllers, chooses weather optimal routes

Current Activities

US Tailored Arrivals
BOEING, NASA, UAL
ZOA, ATO (Oceanic), SFO

Louisville Operations
UPS, SF21, MITRE, NASA
EUROCONTROL

4D Trajectory Exchange

ASAS spacing and merging

CO-ATM

DST and Data link Enhanced Sector Operations

Data link based Multi Sector Operations

Advanced ground system

Trajectory-Oriented Operations with Limited Delegation
NASA

Multi Sector Planner
FAA ATO-P, SJSU, NASA

Advanced Airspace System
NASA

Summary

- Provide scalable framework for greatly increasing capacity (3x by 2025 ?)
- Enable user-preferred routings e.g. CDA's, weather reroutes with minimum deviations (but best equipment gets best service)
- Increase security by having 4D trajectories for all aircraft at all times
- Handle all equipage levels
- Maintain safety
- Provide transition path with gradual shifts in roles and responsibilities
- Enable increased flight deck autonomy if beneficial and authorized by the ATSP
- Combine the advantages of ground-based and airborne separation assurance, but reduce risks resulting from uncoordinated maneuvers, automation dependency, and CNS uncertainties